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Role of Predators and Parasitoids in Tackling Recent Invasive Insect Pests in India

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1. Introduction

India, with its vast geographical area of 3.2 million square kilometres and increasing international trade, is particularly vulnerable to invasive alien species (Singh *et al.*, 2020). Invasive insect species are recognized as the second largest threat to biodiversity, following habitat loss. These pests are responsible for annual agricultural losses estimated at 20-30%. The liberalization of trade and the increased movement of people and goods across continents have accelerated the introduction of invasive pests into India's ecosystems (Daniel *et al.*, 2020). Addressing this challenge requires an integrated approach, with biological control methods, particularly through the use of predators and parasitoids, playing a vital role in regulating invasive pest populations sustainably.

2. Invasive species in India's agricultural ecosystem

India has recorded 34 invasive insect pests alongside 16 fungal pathogens, 5 bacterial pathogens, 3 viruses, 1 nematode, 1 mollusca, and 1 mite, posing significant threats to agriculture and biodiversity. Among insects, Hemiptera leads with 20 species, followed by Lepidoptera (6 species), and Hymenoptera, Diptera, Coleoptera, and Thysanoptera, each contributing 2 species (Harishkumar, 2023). These pests exhibit diverse biological traits and ecological adaptability, causing widespread damage to crops and ecosystems.

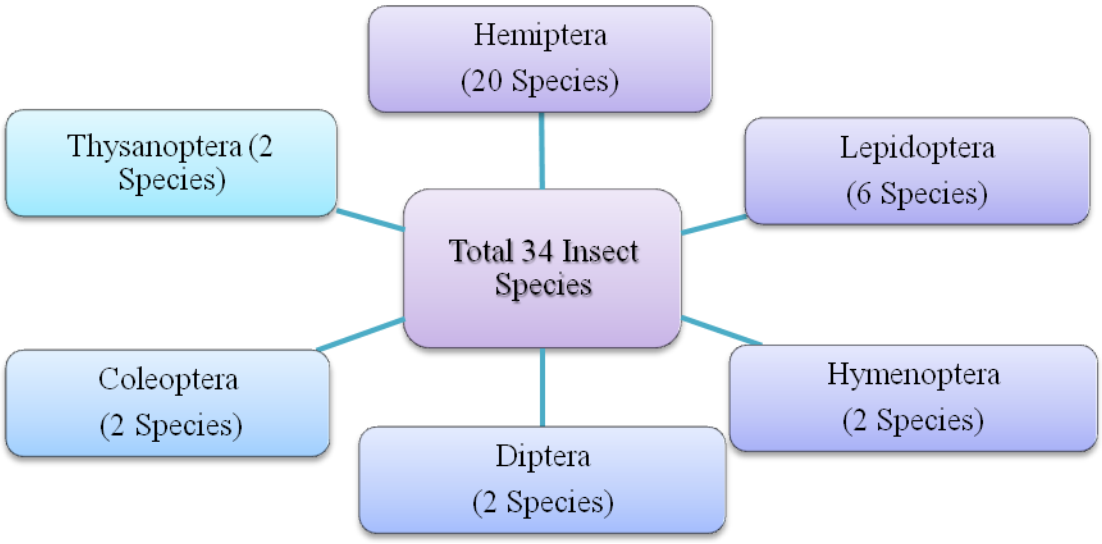

Figure 1. Total number of invasive insect pests in India

3. Characteristics of Invasive Insect Pests:

- Rapid reproduction and multiple generations within a year
- Ability to infest a wide variety of host plants
- Capability to thrive in diverse environmental conditions
- Possess traits like flight, wind-assisted dispersal, or hitchhiking
- Rapidly develop resistance to pesticides
- Introduced through international trade, travel, and transport

4. Recent invasive insect pests in India

India has witnessed the introduction of several invasive insect pests in recent years, posing significant threats to agriculture and forestry (Harishkumar, 2023). Below are some notable invasive pests along with their predators and parasitoids used for biological control.

Papaya mealybug: *Paracoccus marginatus* (Williams and Granara de Willink), F: Pseudococcidae, O: Hemiptera

It is native to Mexico or Central America, entered India through Tamil Nadu in July 2008. It primarily affects crops such as papaya, red gram, cotton, tomato, and guava.

Biological control efforts have introduced several natural enemies, including the parasitoids *Anagyrus loecki*, *Acerophagous papayae*, and *Pseudleptomastrix mexicana* (Hymenoptera: Encyrtidae), which were imported in August 2009.

Madeira mealybug (Hibiscus): *Phenacoccus madeirensis* (Green), F: Pseudococcidae, O: Hemiptera

Native to the Neotropical region, this pest entered India through Karnataka in 2012 and has since impacted crops such as cotton, oats, and citrus. To prevent its spread, natural enemies have been introduced, including predators like *Euseius stipulates* (Phytoseiidae) and *Hyperaspis notata* (Coleoptera: Coccinellidae), as well as parasitoids such as *Acerophagus coccois* and *Acerophagus pallidus* (Hymenoptera: Encyrtidae).

Tomato pinworm / Tomato leaf miner: *Tuta absoluta* (Meyrick) F: Gelechiidae O: Lepidoptera

Originating from South America, the invasive pest was first detected in India in Pune, Maharashtra, in 2014, primarily targeting crops like tomato, datura, and tobacco. To manage this pest, natural enemies have been introduced, including the predator *Nesidiocoris tenuis* (Hemiptera: Miridae) and the parasitoid *Neochrysocharis formosa* (Hymenoptera: Eulophidae).

Western flower thrips: *Frankliniella occidentalis* (Pergande) F: Thripidae, O: Thysanoptera

Native to America, it entered India through Karnataka in 2015 and affects crops such as tomato, beans, capsicum, cucumber, and eggplant. To control its spread, natural enemies have been introduced, including the predator *Orius similis* (Hemiptera: Anthocoridae) and the parasitoid *Ceranisus menes* (Hymenoptera: Eulophidae).

South East Asian thrips: *Thrips parvispinus* (Karny), F- Thripidae, O- Thysanoptera

The invasive pest, native to Thailand, entered India through Bangalore in 2015 and affects crops like papaya, marigold, and pepper. To manage its population, natural enemies have been introduced, including the predator *Orius insidiosus* (Hemiptera: Anthocoridae) and predatory mites such as *Amblyseius swirskii* and *Amblyseius cucumeris* (Acari: Phytoseiidae).

Eucalyptus gall wasp (Bluegum chalcid): *Leptocybe invasa* (Fisher & La Salle), F: Eulophidae, O: Hymenoptera.

The invasive pest, originally from Tanzania, East Africa, was first recorded in India in Kerala in 2016. It primarily targets eucalyptus and bloodwood trees. The parasitoid *Quadrastichus mendeli* (Hymenoptera: Eulophidae) has been introduced, proving to be the most effective biological control agent in managing the pest's population.

Rugose spiraling whitefly: *Aleurodicus rugioperculatus* (Martin) F: Aleyrodidae, O: Hemiptera.

It is native to Central America, entered India through Tamil Nadu in 2016, and affects crops like coconut, banana, sapota, mango, and guava. To control this pest, natural enemies have been introduced, including predators such as *Chilocorus nigrita* (Coleoptera: Coccinellidae) and *Cybocephalus sp.* (Coleoptera: Nitidulidae), along with the parasitoid *Encarsia guadeloupae* (Hymenoptera: Aphelinidae), which was introduced to India in 1999.

Brown peach aphid: *Pterochloroides persicae* (Cholodkovsky), F: Aphididae, O: Hemiptera

Native to the Middle East, it was first recorded in the Kashmir Valley of India in 2018. It primarily affects crops like peach and citrus. To manage the pest, natural enemies such as the predator *Harmonia dimidiate* (Coleoptera: Coccinellidae) and the parasitoid *Aphidius colemani* (Hymenoptera: Braconidae) have been identified as effective biocontrol agents.

Fall armyworm: *Spodoptera frugiperda* (J. E. Smith) F: Noctuidae, O: Lepidoptera

The invasive pest, native to America, entered India through Karnataka in 2018, where it targets crops such as maize, rice, sorghum, sugarcane, and other grasses. Predators such as *Forficula sp.* (Dermaptera: Forficulidae) and *Harmonia octomaculata* (Coleoptera: Coccinellidae) help reduce pest populations, while parasitoids like *Ichneumon promissorius* (Hymenoptera: Ichneumonidae) and *Brachymeria ovata* (Hymenoptera: Chalcididae) play a vital role in controlling its spread.

Bondar's nesting whitefly (Coconut) : *Paraleyrodes bondari* (Peracchi) F: Aleyrodidae, O: Hemiptera.

It is native to Central America, was first recorded in Kerala, India, in 2018. It primarily affects crops such as coconut, mango, and almond. Natural enemies have been identified, particularly the predator *Chrysoperla carnea* (Neuroptera: Chrysopidae), which helps in controlling the pest population.

Nesting whitefly (Coconut*): Paraleyrodes minei* (Iaccarino), F: Aleyrodidae, O: Hemiptera

The invasive pest, native to Syria, entered India through Kerala in 2018 and affects crops like coconut, citrus, and mulberry. The predator *Serangium parcesetosum* (Coleoptera: Coccinellidae) and the parasitoid *Encarsia hispida* (Hymenoptera: Aphelinidae), both play crucial roles in controlling pest populations.

Neotropical whitefly: *Aleurotrachelus atratus* (Hempel), F: Aleyrodidae, O: Hemiptera.

Native to Brazil, the invasive pest was first detected in India through Karnataka in 2019, primarily affecting crops such as coconut and areca palms. Parasitoid *Encarsia basicincta* (Hymenoptera: Aphelinidae) and the predator *Dichochrysa astur* (Neuroptera: Chrysopidae) have been identified as potential agents against this insect pest.

Woolly whitefly: *Aleurothrixus floccosus* (Maskell) F: Aleyrodidae O: Hemiptera.

The invasive pest, native to Jamaica, entered India through Kerala in 2020, targeting crops like guava and citrus. To manage the pest, natural enemies have been introduced, including the parasitoid *Amitus spiniferus* (Hymenoptera: Platygasteridae) and the predator *Acletoxenus formosus* (Diptera: Drosophilidae).

Cassava mealybug: *Phenacoccus manihoti* (Matile-Ferrero), F: Pseudococcidae, O: Hemiptera

Originating from Argentina, the pest entered India via Kerala in 2020, primarily affecting cassava and other species of Manihot. Natural enemies such as the parasitoid *Apoanagyrus lopezi* (Hymenoptera: Encyrtidae) and the predator *Scymnus coccivora* (Coleoptera: Coccinellidae) have been identified as effective biocontrol agents.

Apple leaf blotch miner: *Leucoptera malifoliella* (Costa), F: Lyonetiidae, O: Lepidoptera)

It is native to Europe, entered India through Kashmir in 2023, affecting crops such as apple, pear, and peach. Currently, no native parasitoids have been recorded in India, but the parasitoid *Chrysocharis pentheus* (Hymenoptera: Eulophidae), along with predators like earwigs, has shown promising results in Europe for controlling the pest.

Mango soft scale: *Fistulococcus pokfulamensis* (Hodgson & Martin) (Hemiptera: Coccidae)

The invasive pest, native to Hong Kong, entered India through Karnataka in 2023, affecting crops like mango and jamun. While no native parasitoids have been recorded in India to date, natural predators such as ladybugs and green lacewings, which are indigenous to the region, can be utilized for the pest's biological control.

5. Legal and Institutional Needs

In India, the Directorate of Plant Protection Quarantine and Storage (DPPQ&S) enforces the Destructive Insect and Pest Act (DIPA), 1914, under the Plant Quarantine (Regulation of Import into India) Order, 2003. This framework aims to prevent the entry, establishment, and spread of exotic plant pests, safeguarding agriculture, horticulture, and forest tree plants. The National Bureau of Agricultural Insect Resources (NBAIR), formerly known as NBAII, located in Bangalore, Karnataka, conducts research on the biosystematics of key insect bioagents (Mandal, 2011). It also serves as the nodal agency for the collection, documentation, conservation, and utilization of agriculturally important insect resources, including mites and spiders, to promote sustainable agriculture.

6. Conclusion

Natural enemies, particularly predators and parasitoids, play a pivotal role in managing invasive insect pests recently introduced to India. These biological control agents offer an eco-friendly and cost-effective alternative to conventional chemical pesticides, reducing their usage while promoting sustainable agricultural practices. By integrating predators and parasitoids into pest management strategies, it is possible to mitigate the environmental and health risks associated with chemical controls, ensuring long-term agricultural productivity and ecological balance.

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